



Knowledge-based Economy in Latin America

The LA KLEMS-IADB project

Matilde Mas and Eva Benages

Sixth World KLEMS Conference
March, 2021

OBJECTIVES

- Going a step further in the analysis of LA KLEMS countries' economic performance: an alternative approach to measuring the knowledge economy (Pérez and Benages (2012), Maudos, Benages and Hernández (2017) and Mas, Hofman and Benages (2019a, 2019b)).
- Sensivity analysis of the results according to two approaches, depending on the definition of knowledge-based inputs.
- Analyzing the situation of new countries incorporated to LA KLEMS database in April 2020: Costa Rica, El Salvador, Mexico, Peru and the Dominican Republic.
- Comparison with United States and Spain, which are used as benchmarks.

KNOWLEDGE-BASED ECONOMY. Methodology

Methodological references: Pérez and Benages (2012), Maudos, Benages and Hernández (2017) and Mas, Hofman and Benages (2019a, 2019b).

Knowledge-based economy is defined as the knowledge embedded in both production factors, labor and capital.

The approach consists in measuring the value of knowledge-based activities, using the growth accounting methodology as its framework, which measures the contribution of each productive input (basically, capital and labor) to gross value added (GVA).

The idea consists in measuring the knowledge-based economy by calculating the part of GVA which remunerates the production factors that incorporate knowledge:

- In the case of **labor**, the distinction between knowledge and non-knowledge is based on the distribution by level of **educational attainment** (also by occupation in Maudos et al., 2017).
- In the case of **capital**, this distinction is based on the distribution by **asset type**.

KNOWLEDGE-BASED ECONOMY. Methodology

The value added - $V_j P_j^V$ - by sector j is distributed among the various factors which participate in the productive process, such that:

$$V_j P_j^V = \sum_{i=1}^m L_{ij} * P_{ij}^L + \sum_{h=1}^n K_{hj} * P_{hj}^K$$

Where V_j is the value added in real terms in sector j and P_j^V is the price of sector j GVA; L_{ij} represents the amount of class i labour used in sector j ; K_{hj} represents the amount of class h capital used in that same sector (j); P_{ij}^L is the unit wage paid for class i labour performed in sector j and P_{hj}^K is the cost of using class h capital in sector j ;

Assuming f classes of unskilled labour and that wages provide a proxy for the services that different types of labour provide, the value of labour can be broken down into two parts, the second measuring the value of skilled labour services ($m-f$):

$$\sum_{i=1}^m L_{ij} * P_{ij}^L = \sum_{i=1}^f L_{ij} * P_{ij}^L + \sum_{i=f+1}^m L_{ij} * P_{ij}^L$$

The value added generated by physical capital can be broken down into two major categories: capital that does not incorporate significant amounts of knowledge (g assets) and capital that does ($n - g$ assets, this category including assets with higher user costs):

$$\sum_{h=1}^n K_{hj} * P_{hj}^K = \sum_{h=1}^g K_{hj} * P_{hj}^K + \sum_{h=g+1}^n K_{hj} * P_{hj}^K$$

KNOWLEDGE-BASED ECONOMY. Methodology

The value added generated by knowledge-intensive inputs (labour and capital), or knowledge-based GVA ($KwVA_j$), in sector/activity j can be defined as:

$$KwVA_j = \sum_{i=f+1}^m L_{ij} * P_{ij}^L + \sum_{h=g+1}^n K_{hj} * P_{hj}^K$$

And the knowledge-based GVA share is the amount of each industry GVA that is used to remunerate knowledge-intensive labour or capital:

$$\%KwVA_j = [\sum_{i=f+1}^m L_{ij} * P_{ij}^L + \sum_{h=g+1}^n K_{hj} * P_{hj}^K] / V_j P_j^V$$

Given the knowledge content of each industry, the knowledge intensity of an economy depends on the weight of the various branches in the aggregate. Therefore, if q industries exist, the knowledge intensity of the economy as a whole ($KwVA$) is defined as,

$$\%KwVA = \sum_{j=1}^q \%KwVA_j [V_j P_j^V / VP^V]$$

KNOWLEDGE-BASED ECONOMY. Practical implementation

Identification of the knowledge-based factors: Broad vs. restrictive approach

a) Knowledge-intensive labour

	Classification according to the broad definition	Classification according to the restrictive definition
Tertiary education (ISCED11 5-8, ISCED97 5-6)	Knowledge-intensive labour	Knowledge-intensive labour
Upper secondary education (ISCED 3-4)	Knowledge-intensive labour	Non-Knowledge intensive labour
Below upper secondary education (ISCED 0-2)	Non-Knowledge intensive labour	Non-Knowledge intensive labour

b) Knowledge-intensive capital

Classification according to the broad definition	Classification according to the restrictive definition
1. Non-knowledge intensive assets	1. Non-knowledge intensive assets
1.1. Dwellings	1.1. Dwellings
1.2. Non-residential structures	1.2. Non-residential structures
2. Knowledge-intensive assets	1.3. Transport equipment
2.1. Transport equipment	1.4. Machinery, equipment and other assets
2.2. Machinery, equipment and other assets	2. Knowledge-intensive assets
2.3. ICT assets	2.1. ICT assets

KNOWLEDGE-BASED ECONOMY. Statistical data

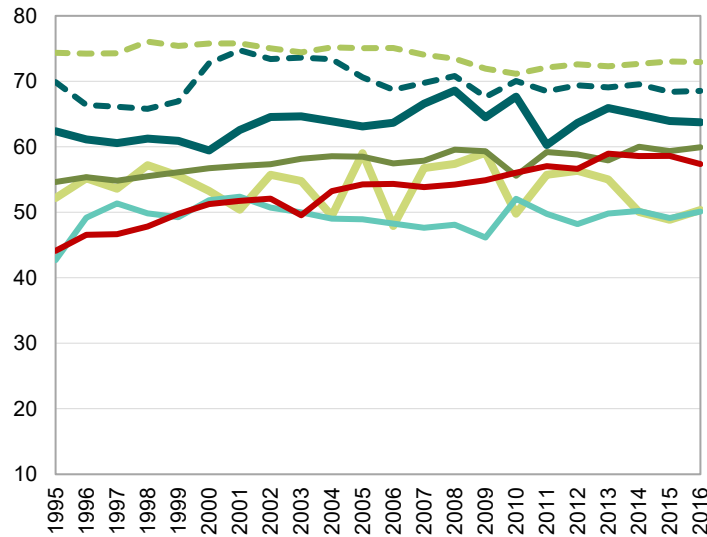
KLEMS databases: LA KLEMS (Costa Rica, El Salvador, Mexico, Peru and the Dominican Republic) and EU KLEMS (Spain and the US), 1995-2016

- KLEMS databases offer information on GVA by industry, labour compensation by industry and capital compensation by industry (consistent with NA data).
- In order to classify **capital compensation** by asset, KLEMS GFCF and capital data can be used to estimate the part of the capital compensation corresponding to each asset type and industry.
 - Information on NA intangible assets are not available for all LA countries. Because of that, these assets are not considered when calculating knowledge-based GVA
- In order to classify **labor compensation**, KLEMS labor data distinguish among different groups of educational attainment (no information by occupation).
- In the case of Spain and the US, we use additional sources to update and supplement the EU KLEMS database (BBVA Foundation-Ivie, BLS and BEA).

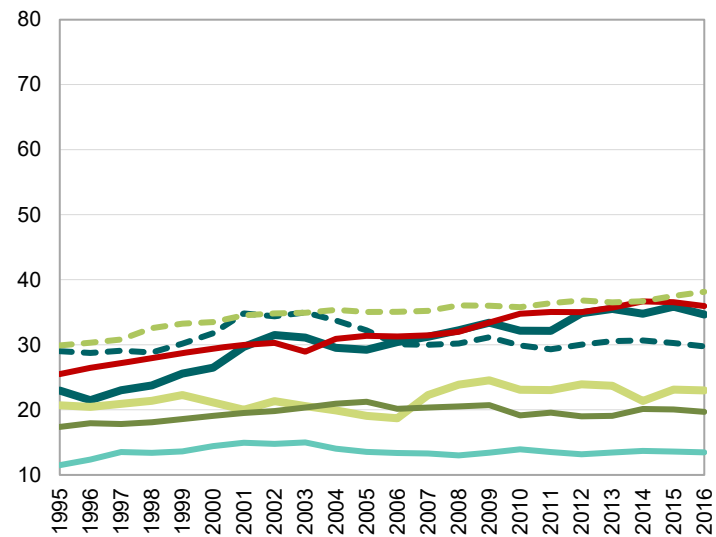
KNOWLEDGE-INTENSITY ESTIMATES. AGGREGATED RESULTS

Figure 1. Knowledge-based GVA. International comparison, 1995-2016
(percentage over total GVA)

a) Broad approach



b) Restrictive approach



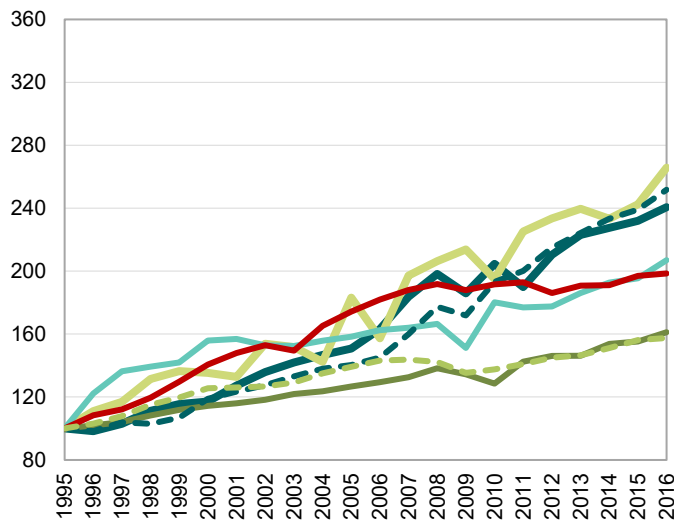
— Costa Rica — Dominican Rep. — El Salvador — Mexico - - - Peru — Spain - - - USA

- Broad approach: the US presents the highest share. Among the LA countries, Peru has the highest share, followed by Costa Rica.
- Restrictive approach: the US still holds the leading position, but now Spain ranks second and the gap between LA countries and the US is higher.
- Two clusters of LA countries: Costa Rica and Peru follow a common pattern, showing a higher share of knowledge-based GVA more similar to that of the US and Spain. Mexico, the Dominican Republic and El Salvador form the second cluster of lagging countries.

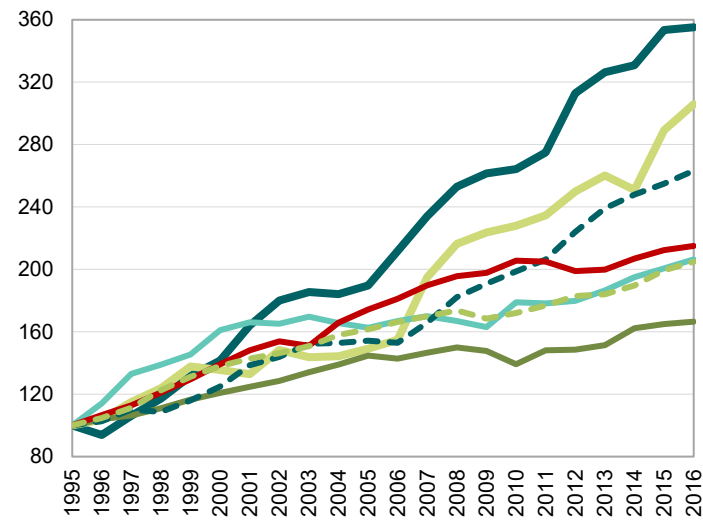
KNOWLEDGE-INTENSITY ESTIMATES. AGGREGATED RESULTS

Figure 2. Real knowledge-based GVA. International comparison, 1995-2016
(1995=100)

a) Broad approach



b) Restrictive approach



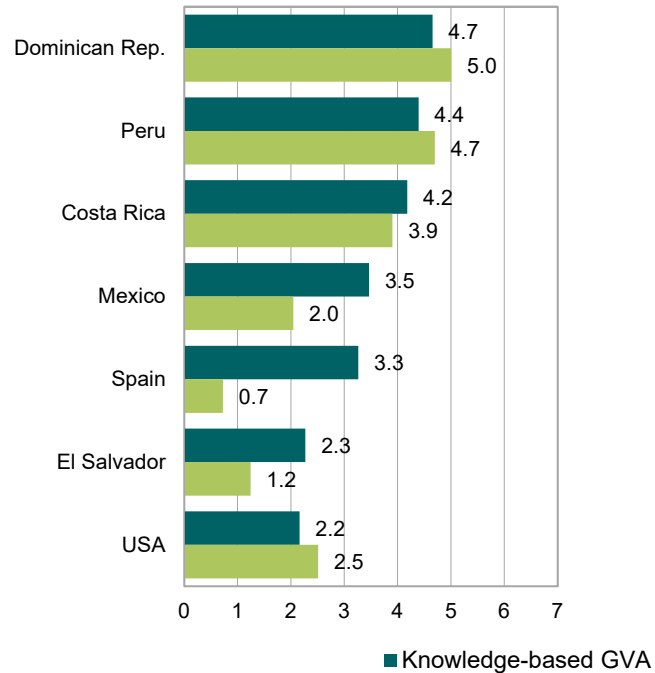
— Costa Rica — Dominican Rep. — El Salvador — Mexico - - - Peru — Spain - - - USA

- The knowledge-based GVA calculated following the restrictive definition shows a more dynamic behaviour.
- Knowledge-based GVA growth is particularly intense in Costa Rica, the Dominican Republic and Peru.
- Overall, there was some convergence over the period 1995-2016 (Mexico and El Salvador seem to be the exceptions)

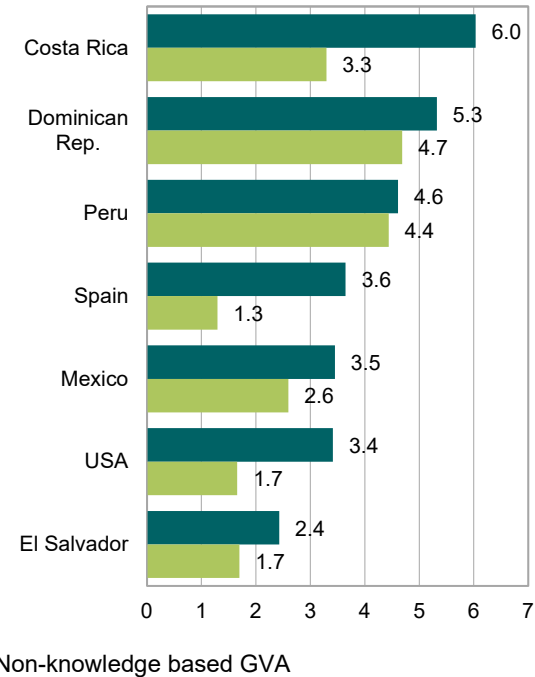
KNOWLEDGE-INTENSITY ESTIMATES. AGGREGATED RESULTS

Figure 3. Average growth rate of knowledge and non-knowledge GVA. International comparison, 1995-2016 (percentage)

a) Broad approach



b) Restrictive approach

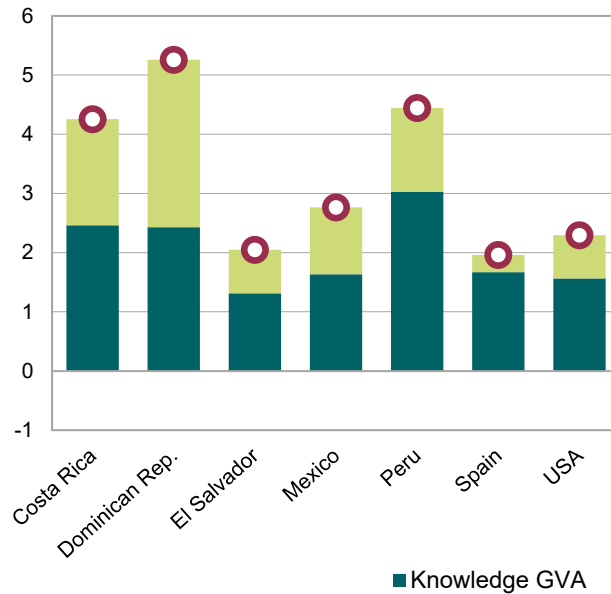


- Under the broad approach, the knowledge-based GVA grows more than its non-knowledge counterpart in Costa Rica, Mexico, El Salvador and Spain.
- Under the restrictive approach, the knowledge-based GVA grows more than its non-knowledge counterpart in all the countries, confirming the higher dynamism of the most technological assets and the most educated workers in generating value added.

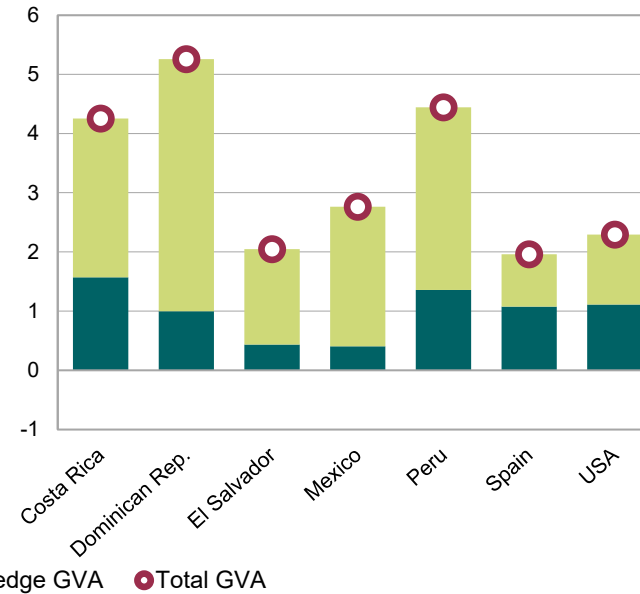
KNOWLEDGE-INTENSITY ESTIMATES. AGGREGATED RESULTS

Figure 4. GVA annual growth rate: knowledge and non-knowledge contribution. International comparison, 1995-2016 (percentage)

a) Broad approach



b) Restrictive approach

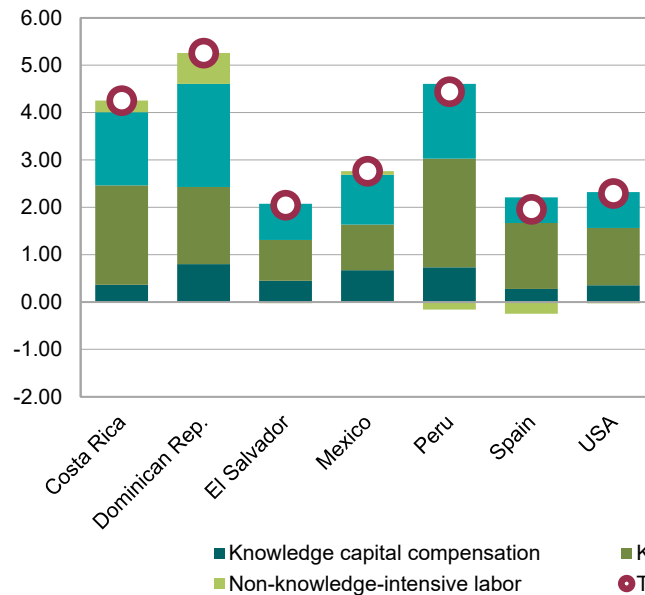


- Under the broad approach, the contribution of knowledge-based GVA is higher than that of non-knowledge GVA in almost all the countries.
- Under the restrictive definition, the contribution of knowledge-based GVA is only greater or similar to that of the non-knowledge GVA in Spain and the US. LA countries are still lagging behind in terms of the contribution to growth of the most knowledge-intensive factors.

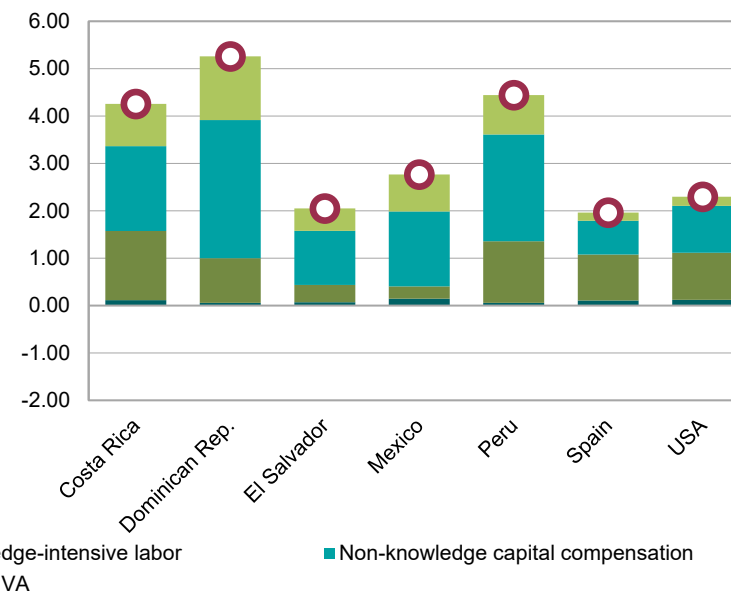
KNOWLEDGE-INTENSITY ESTIMATES. AGGREGATED RESULTS

Figure 5. Knowledge and non-knowledge capital and labor contribution to annual real GVA growth rate. International comparison, 1995-2016 (percentage)

a) Broad approach



b) Restrictive approach

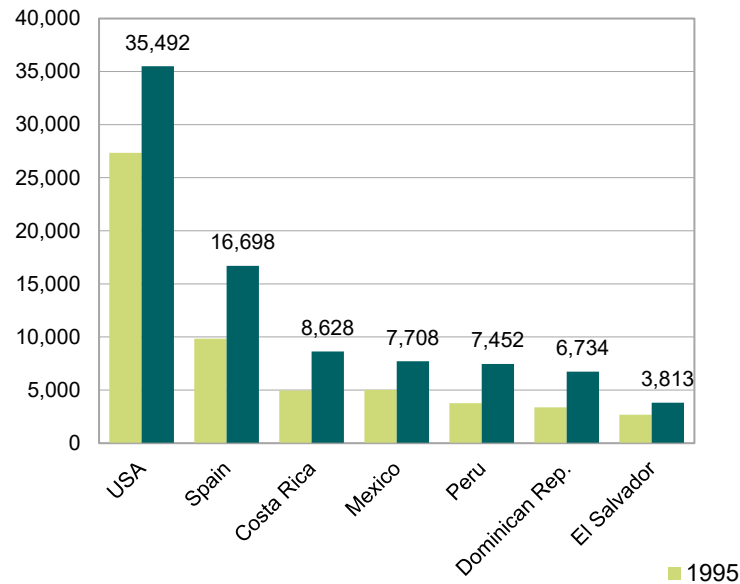


- In general, knowledge-intensive labor make a higher contribution to GVA growth than knowledge-intensive capital. This is particularly true for the most developed countries.
- The contribution of non-knowledge capital is much greater in Latin American countries, especially in Peru and the Dominican Republic.
- In all the countries the contribution of non-knowledge-intensive capital is higher than its knowledge-intensive counterpart. However, in most countries the contribution of non-knowledge-intensive labor was lower than its knowledge-intensive counterpart.

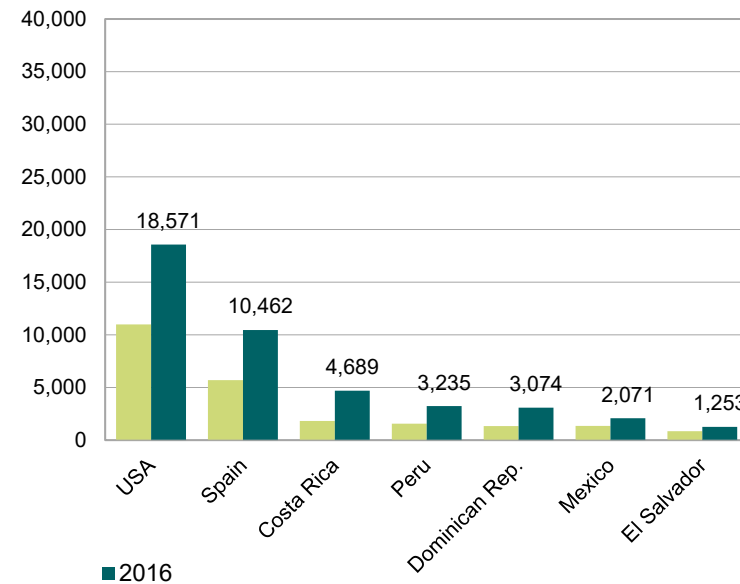
KNOWLEDGE-INTENSITY ESTIMATES. AGGREGATED RESULTS

Figure 6. Knowledge-based GVA per capita. International comparison, 1995 and 2016 (2010 US Dollars PPP per person)

a) Broad approach



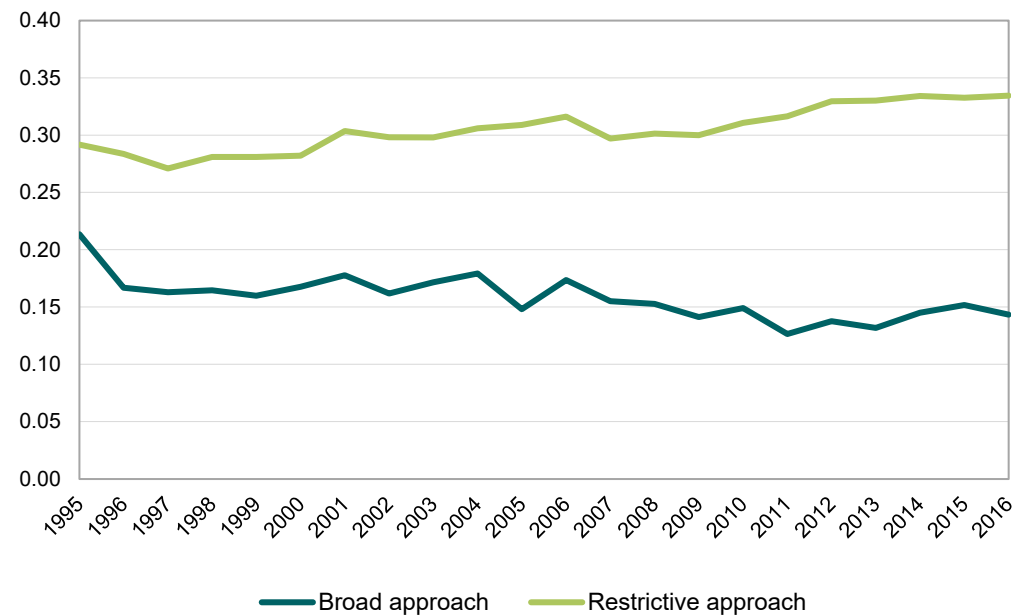
b) Restrictive approach



- Regardless of the approach, the two benchmark countries lead the ranking and the gap between them and the LA countries is significant.
- Among LA countries, Costa Rica leads the ranking and El Salvador is in last place.
- All the countries have experienced an improvement between 1995 and 2016 for both approaches.

KNOWLEDGE-INTENSITY ESTIMATES. AGGREGATED RESULTS

Figure 7. Convergence in the knowledge-based GVA share among countries. 1995-2016 (coefficient of variation)

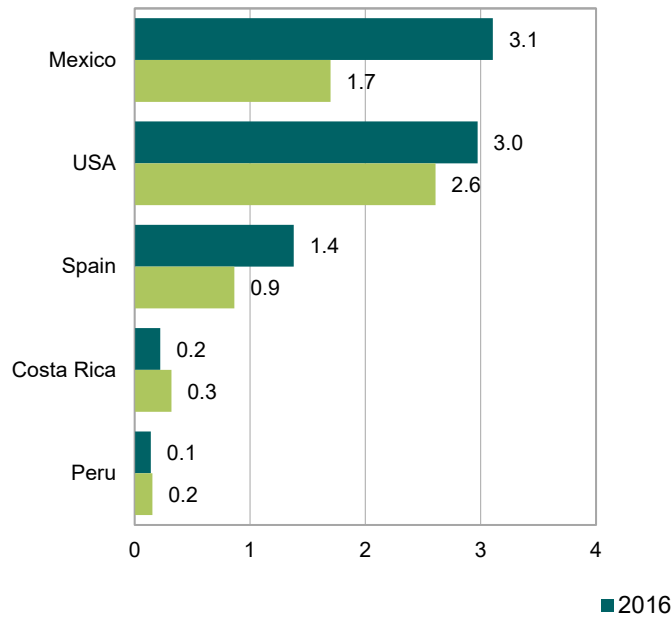


- The differences among countries under the restricted approach are higher, with a slight increase throughout the period 1995-2016.
- Conversely, when the broader approach is considered, there is convergence. This result may imply that, in general, LA countries have advanced more in terms of the use of machinery and equipment and medium-skilled workers than in terms of technologically advanced assets and most educated labor.

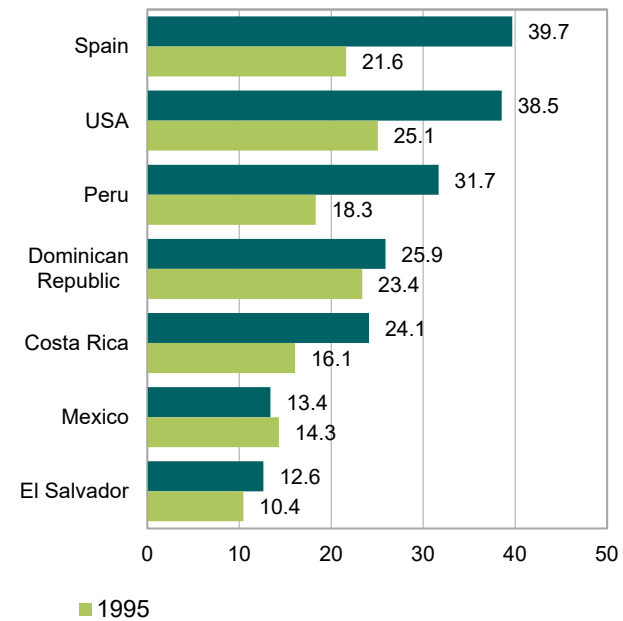
KNOWLEDGE-INTENSITY ESTIMATES. AGGREGATED RESULTS

Figure 8. Results from traditional methods to measure the knowledge economy. International comparison, 1995 and 2016

a) R&D intensity (percentage over GVA)



b) Hours worked by high-skilled workers (percentage over total hours)



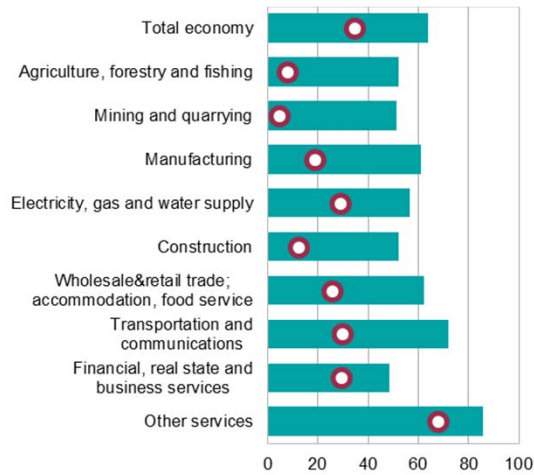
Note: Countries are ranked according to 2016.

- Our conclusions are in line with those derived from the analysis of human capital but differ significantly from those based on the analysis of R&D intensities. These differences are explained by the focus of our approach on the use of knowledge by the economic system, rather than on its generation or creation, which can be associated with R&D investment figures.

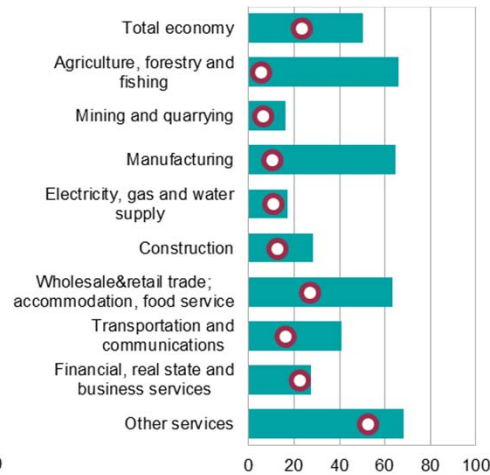
KNOWLEDGE-INTENSITY ESTIMATES. DISAGGREGATED RESULTS BY INDUSTRY

Figure 9. Knowledge-based GVA by industry. Broad and restrictive approach, 2016 (percentage of each industry's GVA. Total industry=100)

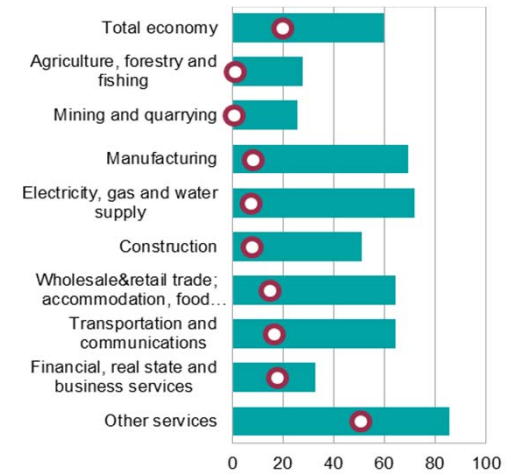
a) Costa Rica



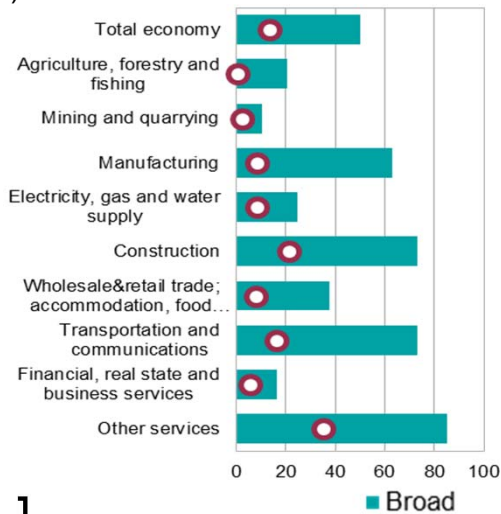
b) Dominican Republic



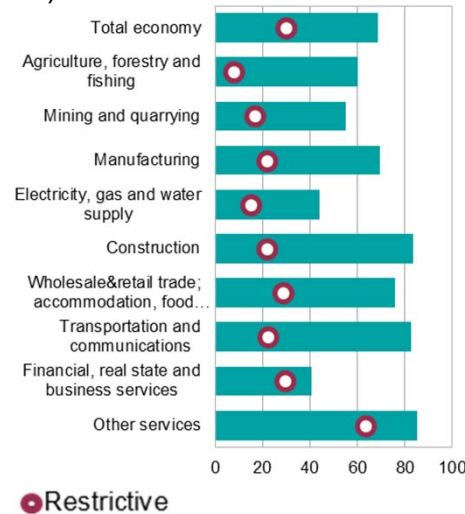
c) El Salvador



d) Mexico



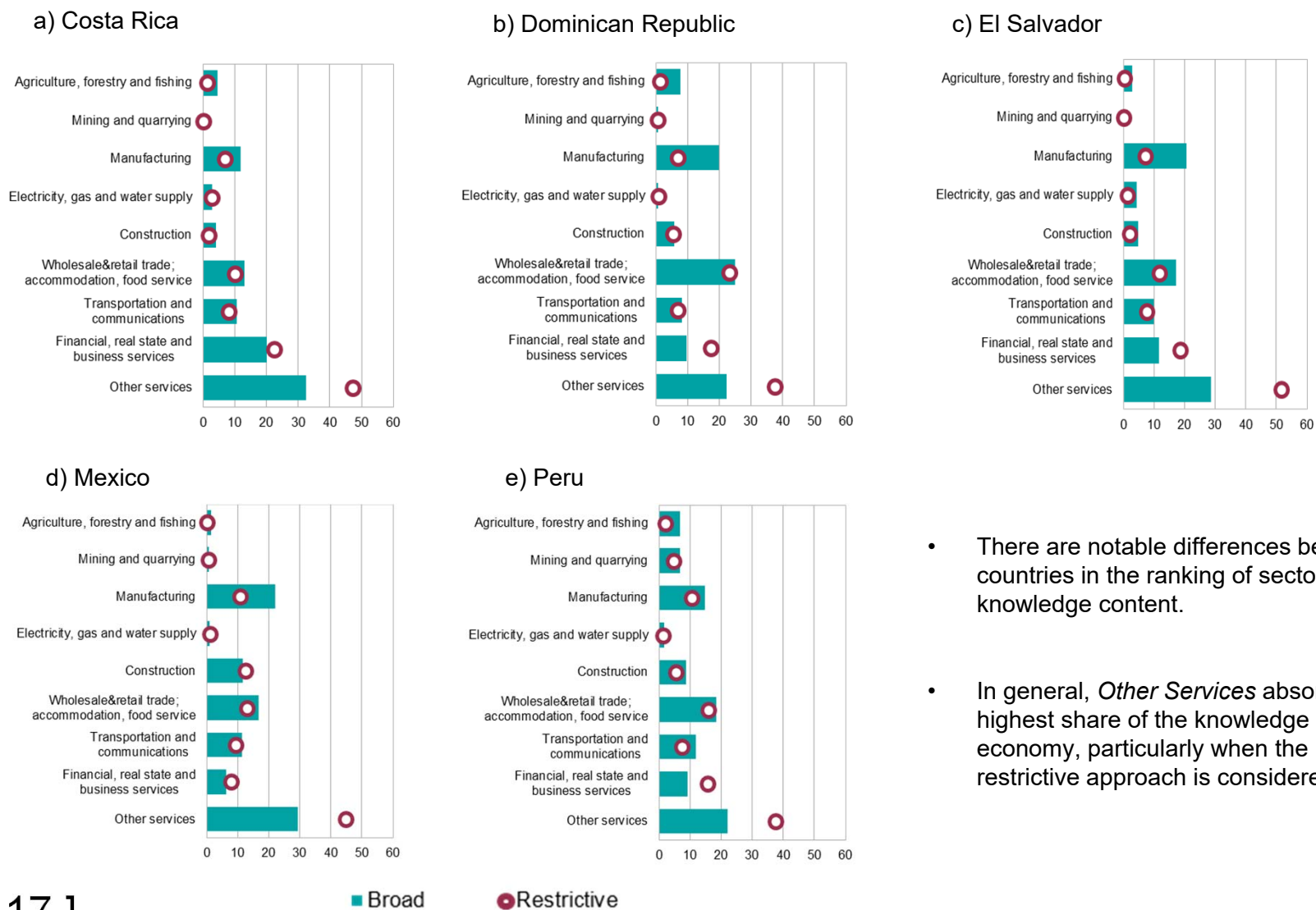
e) Peru



- There are important differences in terms of knowledge intensity by industry and also by countries within the same industry.
- The more developed a country is, the more evenly the knowledge economy is spread across all the sectors of the economy.

KNOWLEDGE-INTENSITY ESTIMATES. DISAGGREGATED RESULTS BY INDUSTRY

Figure 10. Knowledge-based GVA by industry. Broad and restrictive approach, 2016 (percentage of total knowledge-based GVA)

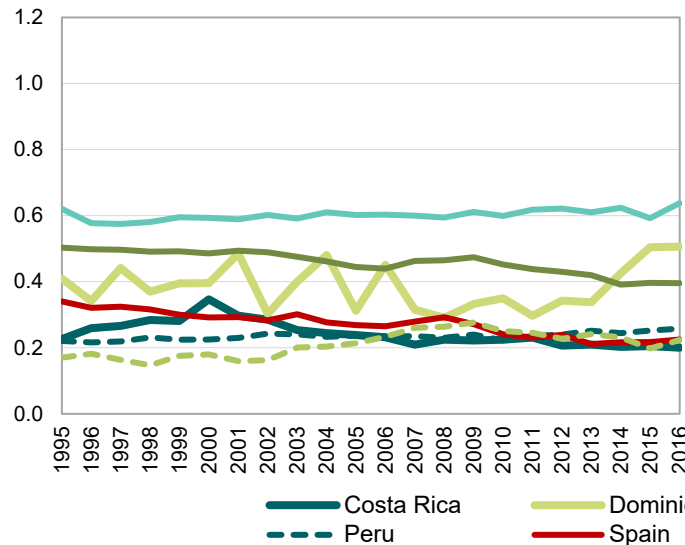


- There are notable differences between countries in the ranking of sectors by knowledge content.
- In general, *Other Services* absorbs the highest share of the knowledge economy, particularly when the restrictive approach is considered.

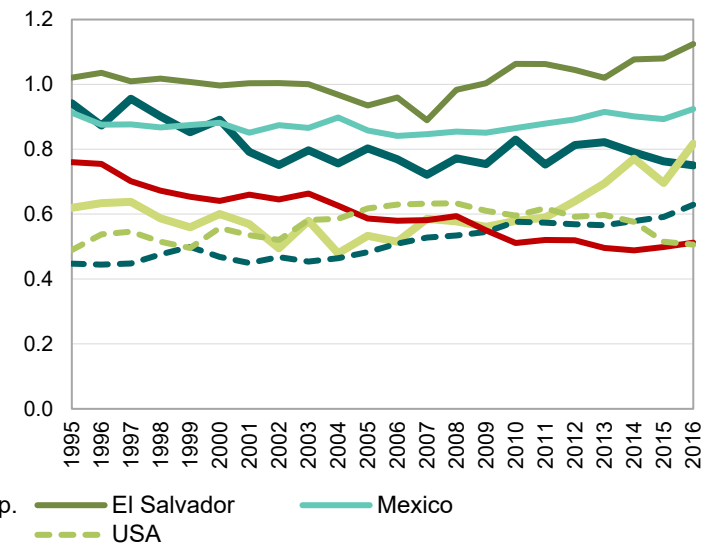
KNOWLEDGE-INTENSITY ESTIMATES. DISAGGREGATED RESULTS BY INDUSTRY

Figure 11. Convergence in the knowledge GVA share among industries, 1995-2016 (coefficient of variation)

a) Broad approach



b) Restrictive approach

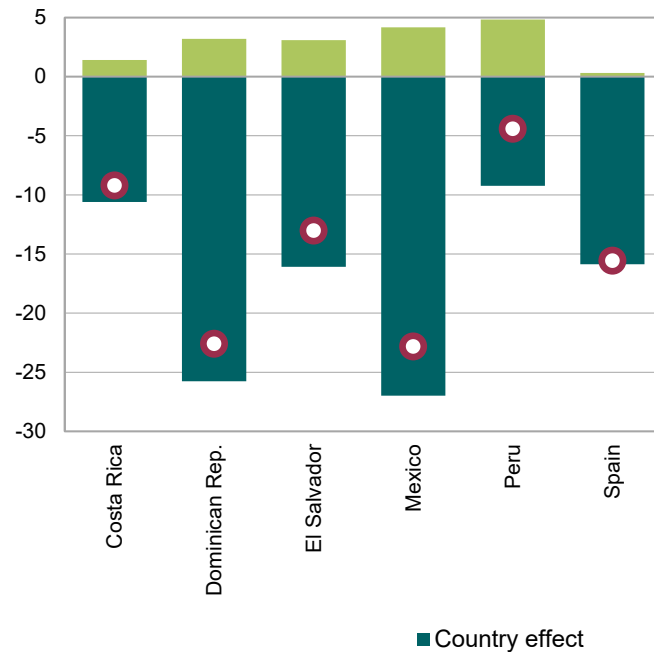


- There is no general pattern of convergence towards less dispersion between industries and the dispersion among industries is higher when we consider the restrictive approach.
- Mexico is the country with the highest dispersion under the broad approach, whereas El Salvador leads when the restrictive approach is considered.
- The US and Spain are the countries with the lowest dispersion, regardless of the approach, together with Costa Rica and Peru. This result confirms that the more developed economies have a more homogenous penetration of knowledge in the different sectors.

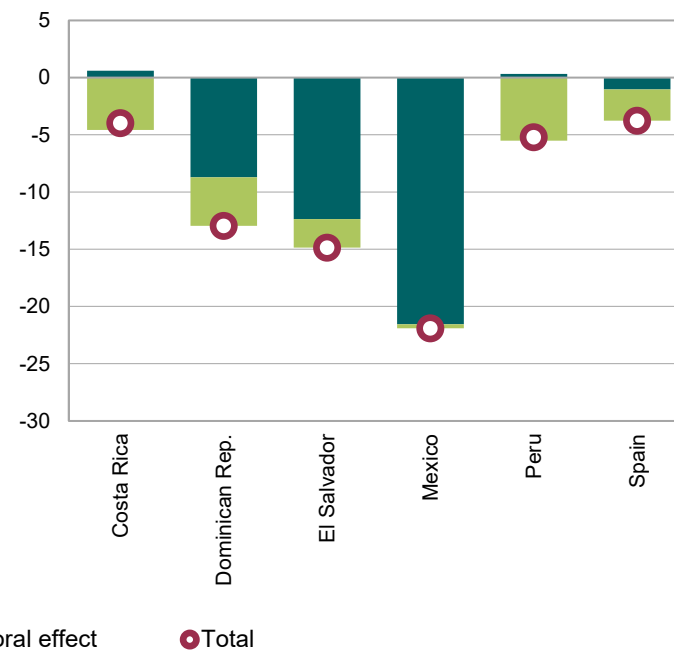
KNOWLEDGE-INTENSITY ESTIMATES. DISAGGREGATED RESULTS BY INDUSTRY

Figure 12. Shift-share analysis of the knowledge-based GVA share. Difference with benchmark country (USA), 2016 (percentage points)

a) Broad approach



b) Restrictive approach



- The country effect is by far the most important determinant of the knowledge intensity differences between all countries and the US, regardless of the approach.
- Then, the most important lever to reduce the differences from the leading country is the penetration of knowledge in all sectors of the economy, more than a sectoral change towards a more similar sectoral structure to that of the benchmark country.

However, we must take into account that our sectoral classification detail is rather limited (9 sectors)

CONCLUSIONS

- The Latin American countries can be clustered in two groups. Costa Rica and Peru follow a common pattern, showing a higher share of knowledge-based GVA, more similar to that of the US or Spain, the benchmark countries. Mexico, the Dominican Republic and El Salvador form the second cluster.
- The comparison of the results from the two approaches suggests that the restricted approach tends to favor the most developed countries.
 - It may be better to focus on the restrictive approach when we want to analyze advanced countries or the gap between less developed countries and benchmark countries. On the other hand, it may be more appropriate to focus on the broad approach when we are analyzing less developed countries.
- knowledge-based GVA calculated following the restrictive definition is more dynamic than under the broad definition, meaning that the value generated by the most technological assets and the most educated workers has grown more intensively in all countries.
- There was some convergence over the period 1995-2016 among the countries analyzed when we consider the broad approach, but not when the restricted approach is considered.
- In almost all the countries, knowledge-intensive labor contributed more to GVA growth than knowledge-intensive capital. This is particularly true for the most developed countries.

CONCLUSIONS

- When our results are compared with other traditional measures to assess the knowledge economy, important differences arise. They can be explained by:
 - the consideration of more than one single factor (as in the case of R&D intensity)
 - the fact that our objective is to measure the use of knowledge by the economic activities and not only knowledge generation, and
 - the consideration of the remunerations for the different factors of production in addition to their physical or absolute quantities.
- From the sectoral perspective, in almost all countries, the sector *Other services* (which includes *Public administration, Education, Health, Social services, Arts, entertainment and recreation and other services*) absorbs the highest share of the knowledge economy.
- The penetration of knowledge in all the sectors of the economy seems to be more relevant than sectoral change towards more advanced sectors. It seems that the more developed a country is, the more evenly the knowledge economy is spread across all the sectors of the economy.
- When analyzing the gap between LA countries and the US, the country effect (i.e., the differences among countries arising from internal variations in the use of knowledge within the same industry) seems to be the main lever to reduce it, instead of fostering a change in sectoral specialization towards industries that are more intensive in the use of knowledge.



Knowledge-based Economy in Latin America

The LA KLEMS-IADB project

Matilde Mas and Eva Benages

Sixth World KLEMS Conference
March, 2021